ADVANCE SOIL MECHANIC

Soil Classification

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Rencana Materi Pembelajaran

UTS

- Klasifikasi Tanah
- Consolidation
  - Vertical drain Analisis
- Seepage

UAS

- Soil Model
- Slope Stability

Penilaian

UTS	: 30%
UAS	: 30%
KUIS + Tugas	: 40%

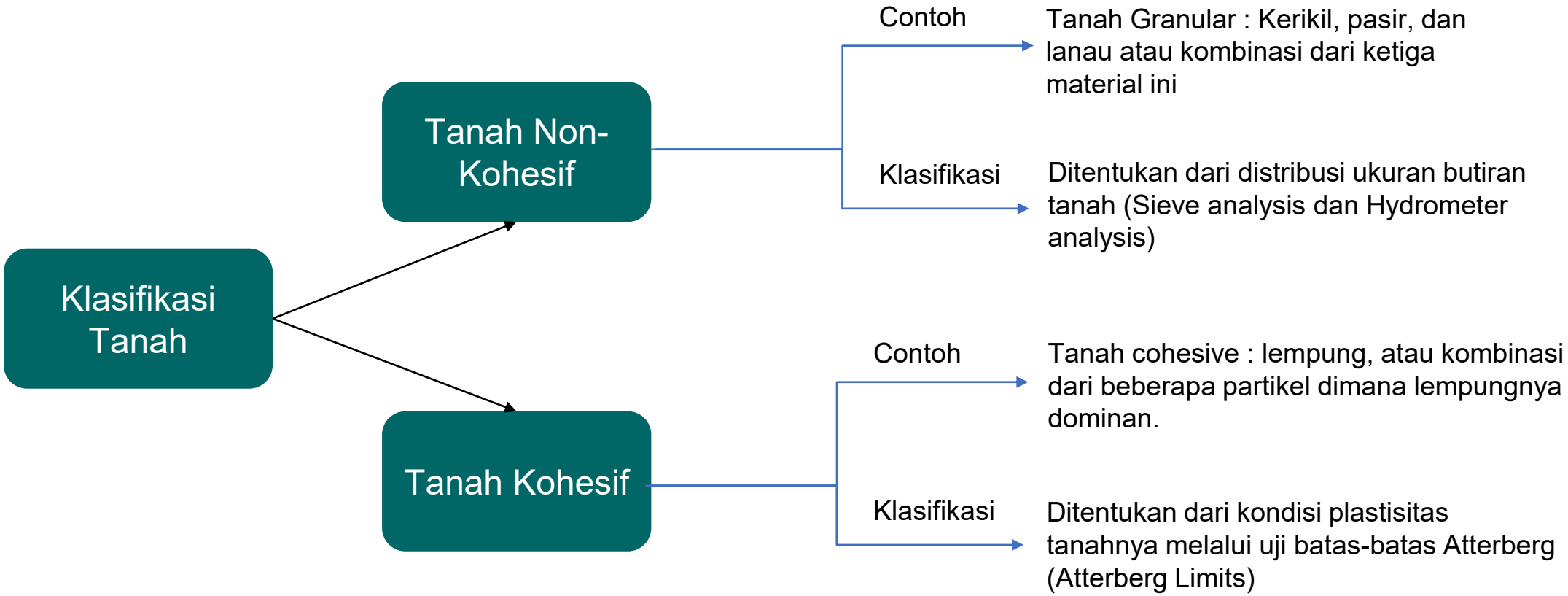
Klasifikasi Tanah

- Di samping penguasaan teori, kesuksesan dalam aplikasi ilmu geotek tergantung dari pengalaman seseorang
- Catatan pengalaman yang menyertakan keadaan tanah merupakan informasi yang sangat berharga
- Untuk mengurangi resiko bahaya dalam perencanaan geoteknik diperlukan suatu sistem KLASIFIKASI TANAH yang bersifat universal

Tujuan

- Agar tanah dapat dikelompokkan berdasarkan penampilan/karakteristik fisiknya, sehingga dapat digunakan untuk membandingkan tanah yang berbeda
- Menjelaskan kegunaan dari masing-masing tanah tersebut untuk jenis pekerjaan tertentu

Soil Classification

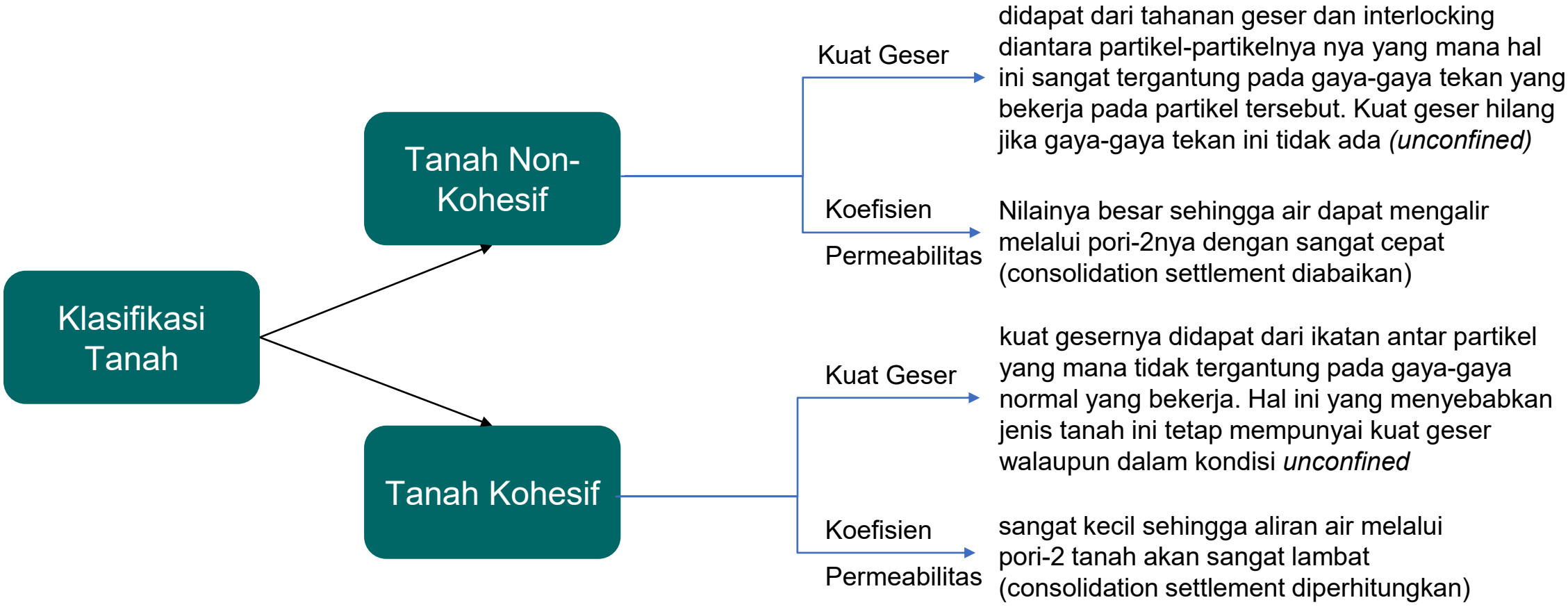


Soil Classification

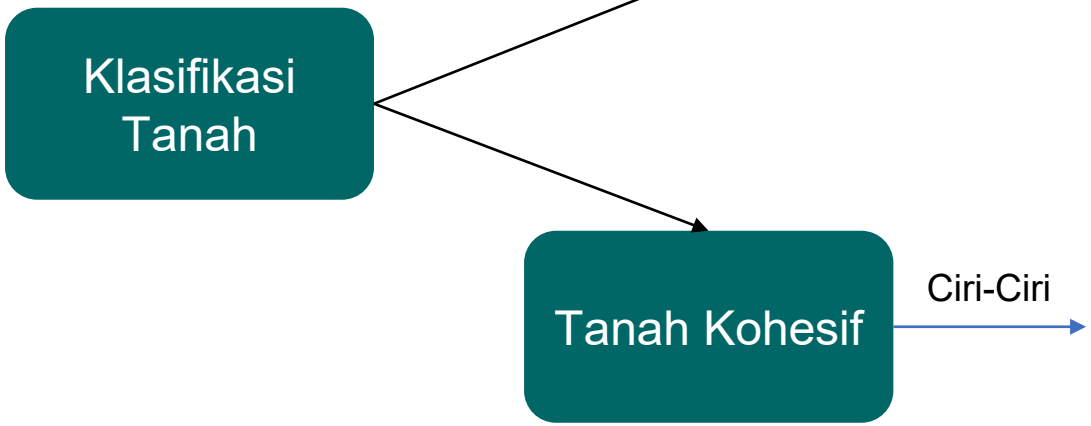
Tanah Non-Kohesif

Tanah Kohesif

Soil Classification



Soil Classification



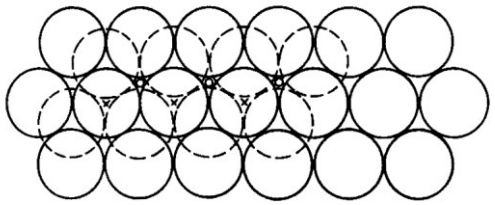
- Partikel Tanah tidak melekat satu sama lain
- Ukuran partikel antara 0.06mm-200mm
- Tanah non-kohesif memiliki nilai lebih dalam konstruksi
- Air tanah mudah keluar karena partikelnya yang berongga

- Partikel butiran halus saling berikatan
- Ukuran partakel lebih kecil dari 0.06mm
- Tingkat kohesif tanah tergantung pada ukuran dan bentuk partikel serta kondisi muka air tanah
- Ketika basah tanah akan lunak dan ketika kering tanah bisa menjadi sangat padat dan keras
- Memiliki tingkat kadar air yang tinggi
- Selalu memiliki riwayat proses kembang dan susut tanah
- Akibat peningkatan level kadar air bisa menyebabkan perbedaan kuat geser tanah

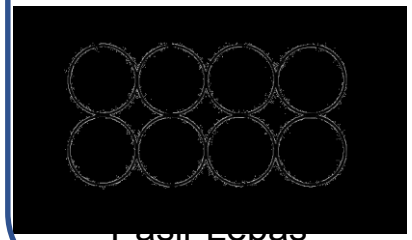
Tekstur, Susunan dan Struktur Partikel Tanah

Susunan Partikel

- Tanah Berbutir Kasar
- Tanah Lempung



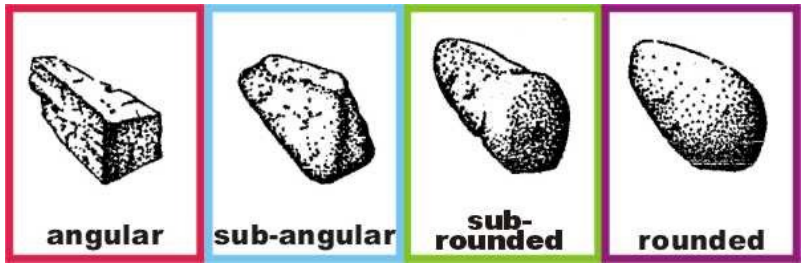
Pasir Padat

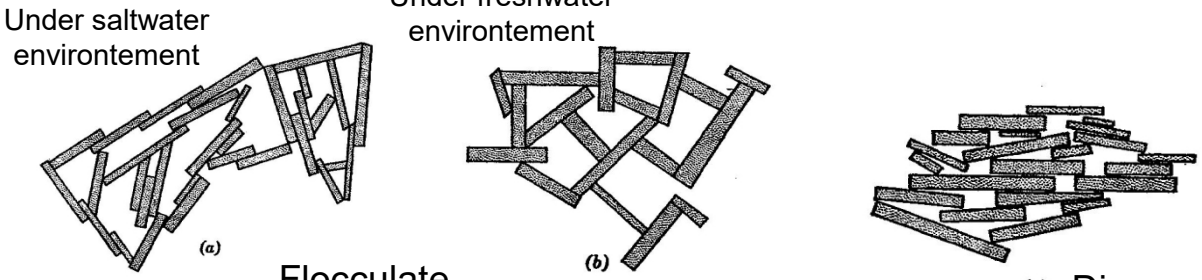


Pasir Lepas

Bentuk Butiran

- *Angular*
- *Subangular*
- *Subrounded*
- *Rounded*





Struktur Partikel Tanah Granular (Non-Kohesif)

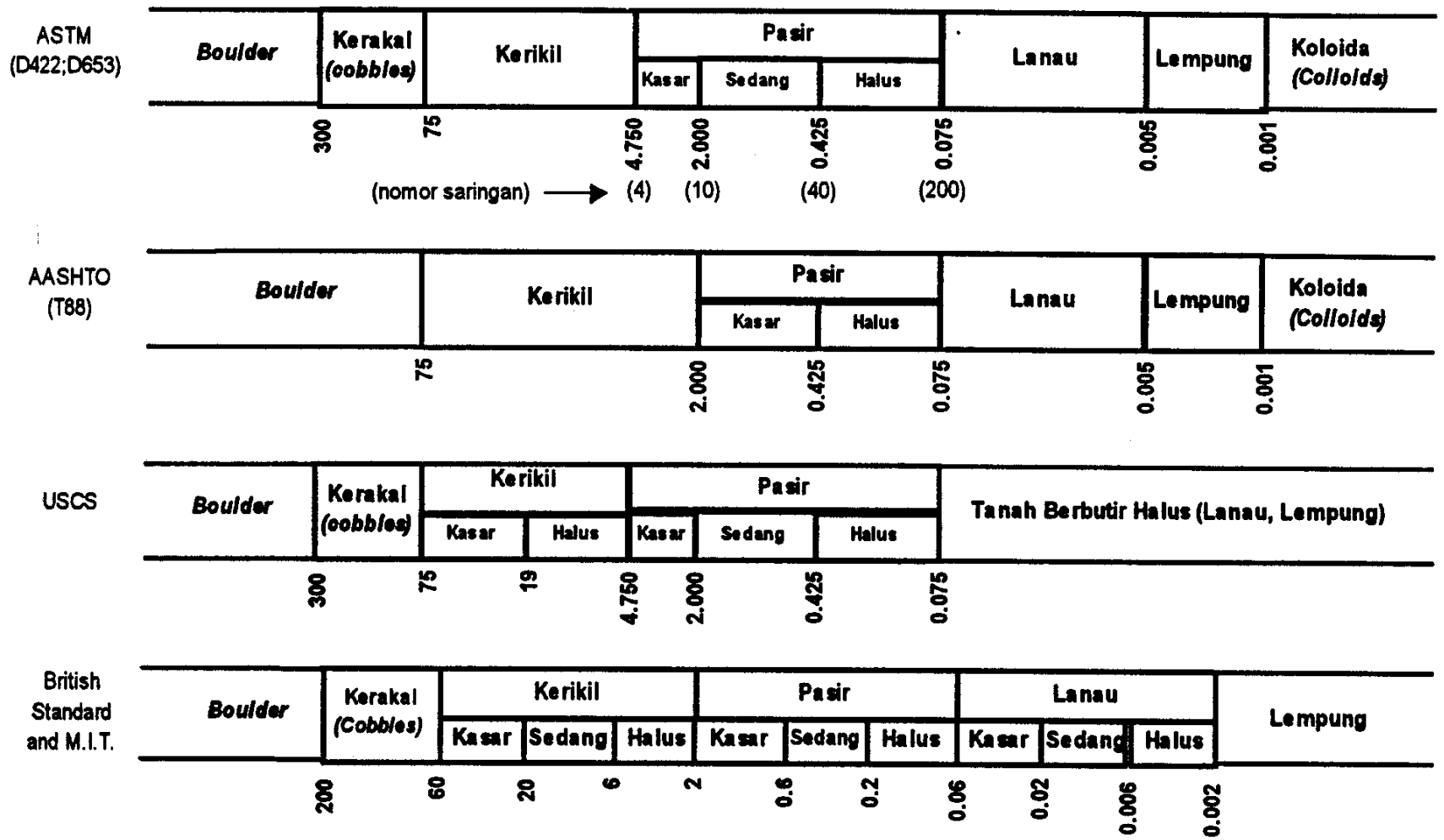
- Nilai void ratio dan porosity dari tanah berbutir kasar umumnya ditentukan oleh 'state of packing' dari butir-butir tanah, yang dapat dibedakan atas: a) kondisi lepas (loosest state) yang menggambarkan kondisi maximum void space, dan b) kondisi padat (densest state) yang menggambarkan kondisi minimum void space. Kondisi pemadatan tanah dilapangan umumnya dinyatakan dengan menggunakan relative density, Dr, yang didefinisikan sbb:

$$D_r = \frac{e_{\max} - e_{\min}}{e_{\max} - e_{\min}}$$

- Berdasarkan nilai Dr maka tingkat kepadatan dari tanah berbutir kasar dapat dibedakan seperti terlihat pada table berikut ini.

State of packing	Relative Density	Standard Penetration Resistance, N blows/ft
Very loose	< 0.2	< 4
Loose	0.2 - 0.4	4 - 10
Medium Dense/ Compact	0.4 - 0.6	10 - 30
Dense	0.6 - 0.8	30 - 50
Very Dense	>0.8	> 50

Kalsifikasi Tanah berdasarkan Ukuran Butiran



Kalsifikasi Tanah berdasarkan Ukuran Butiran

Berdasarkan ukuran butirnya, tanah berbutir kasar dan lanau (silts) dapat dibedakan atas:

• Lanau (silt)	0.002 - 0.060mm
• Pasir (sand)	0.06 - 2.0mm
• Kerikil (gravel)	2 – 60mm
• Cobbles	60 – 200mm
• Boulders	> 200mm

Kalsifikasi Tanah berdasarkan Ukuran Butiran

Pasir dan gravel dibagi lagi atas halus, sedang, dan kasar sbb:

Pasir	halus	0.06 – 0.20 mm
	Sedang	0.20 – 0.60 mm
	Kasar	0.60 – 2.00 mm
Gravel	halus	2.0 – 6.0 mm
	Sedang	6.0 – 20.0 mm
	Kasar	20.0 – 60.0 mm

USCS-Coarse grains

- Tanah berbutir kasar (coarse grains):

Lebih dari 50% tertahan disaringan no.200 (0.075mm)

- Tanah berbutir halus (fine grains):

Lebih dari 50% lolos disaringan no.200 (0.075mm)

USCS-Fine Grains

- Silts (lanau) simbolnya M
- Clays (lempung) simbolnya C
- Organic silts dan organic clays

Tanah berbutir halus dibedakan berdasarkan plasticity index dan liquid limit:

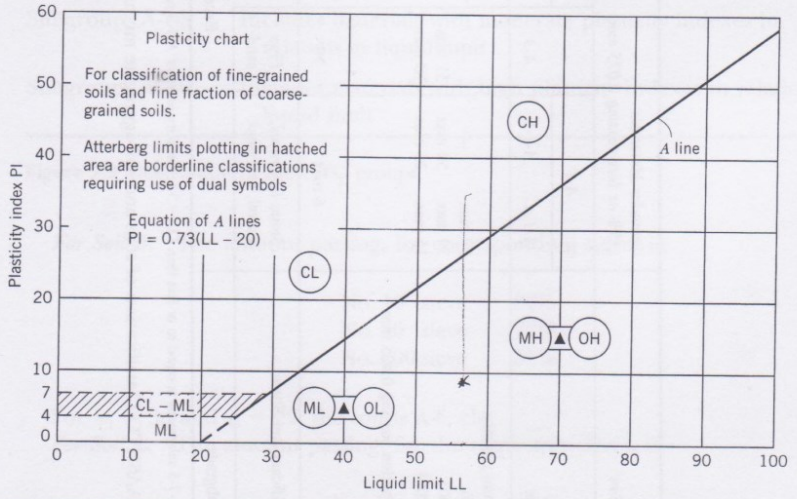
- Low plasticity L, bila Liquid limit < 50%
- High plasticity H, bila liquid limit > 50%

Major Divisions			Group Symbols	Typical Names
Coarse-Grained Soils More than 50% retained on No. 200 sieve*	Gravels 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels −200 <5%	GW	Well-graded gravels and gravel–sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel–sand mixtures, little or no fines
		Gravels with fines −200 >12%	GM	Silty gravels, gravel–sand–silt mixtures
			GC	Clayey gravels, gravel–sand–clay mixtures
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean sands −200 <5%	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly graded sands and gravelly sands, little or no fines
		Sands with fines −200 >12%	SM	Silty sands, sand–silt mixtures
			SC	Clayey sands, sand–clay mixtures
Fine-Grained Soils 50% or more passes No. 200 sieve*	Silts and Clays Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
Highly Organic Soils			PT	Peat, muck, and other highly organic soils

Figure 2.7 Unified Classification System, ASTM D-2487-69.

Classification Criteria

	$C_u = D_{60}/D_{10} > 4$ $\quad C_z = \frac{D_{30}^2}{D_{10}D_{60}}$ between 1 and 3	
	Not meeting both criteria for GW	
Classification on Basis of Percentage of Fines	Atterberg limits plot below *A* line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
Less than 5% pass No. 200 sieve: GW, GP, SW, SP	Atterberg limits plot above *A* line and plasticity index greater than 7	
More than 12% pass No. 200 sieve: GM, GC, SM, SC	$C_u = D_{60}/D_{10} > 6$ $\quad C_z = \frac{D_{30}^2}{D_{10}D_{60}}$ between 1 and 3	
5–12% pass No. 200 sieve: Borderline classification requiring use of dual symbols	Not meeting both criteria for SW	
	Atterberg limits plot below *A* line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
	Atterberg limits plot above *A* line and plasticity index greater than 7	



Visual-manual identification, see ASTM D-2488.

* 0.075-mm sieve.

AASHTO Classification System

- Granular materials: Lebih kecil atau sama dengan 35% lolos saringan 0.075mm
- Silt-Clay materials: Lebih dari 35% lolos saringan 0.075mm
- Group Index (GI):

$$GI = \underbrace{(F - 35)}_{1 \text{ to } 40}[0.2 + 0.005(\underbrace{LL - 40}_{1 \text{ to } 20})] + 0.01(\underbrace{F - 15}_{1 \text{ to } 40})(\underbrace{PI - 10}_{1 \text{ to } 20})$$

AASHTO Classification System

Description of Classification Groups	
Subgroup A-1a	Includes those materials consisting predominantly of stone fragments or gravel
Subgroup A-1b	Includes those materials consisting predominantly of coarse sand, either with or without a well-graded soil binder
Subgroup A-3	Fine beach sand or fine desert loess sand without silty or clay fines or with a very small amount of nonplastic silt
Subgroups A-2-4 and A-2-5	Include various granular materials containing 35% or less passing the 0.075-mm sieve and with a minus 0.425 mm in having the characteristics of the A-4 and A-5 groups
Subgroups A-2-6 and A-2-7	Include material similar to that described under subgrades A-2-4 and A-2-5, except that a fine portion contains plastic clay having the characteristics of the A-6 or A-7 group
Subgroup A-4	The typical materials of this group are the nonplastic or moderately plastic silty soils
Subgroup A-5	Similar to that described under group 2-4, except that it is usually of diatomaceous or micaceous character
Subgroup A-6	Usually a plastic clay having 75% or more passing the 0.075-mm sieve
Subgroup A-7-5	Includes materials with moderate plasticity indexes in relation to liquid limit
Subgroup A-7-6	Includes materials with high plasticity indexes in relation to liquid limit

AASHTO Classification System

General Classification	*Granular Materials (35% or less passing 0.075 mm)*							*Silt-Clay Materials (More than 35% passing 0.075 mm)*			
	A-1			*A-2*							
Group Classification	*A-1-a*	*A-1-b*	*A-3*	*A-2-4*	*A-2-5*	*A-2-6*	*A-2-7*	*A-4*	*A-5*	*A-6*	*A-7-5 A-7-6*
Sieve analysis, percent passing:											
2.00 mm (No. 10)	50 max	—	—	—	—	—	—	—	—	—	—
0.425 mm (No. 40)	30 max	50 max	51 min	—	—	—	—	—	—	—	—
0.075 mm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40)											
Liquid limit	—		—	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity index*	6 max		NP	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min
Usual types of significant constituent materials	Stone fragments, gravel, and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good							Fair to poor			

* Plasticity index of A-7-5 subgroups is equal to or less than LL − 30. Plasticity index of A-7-6 subgroup is greater than LL − 30.

Figure 2.8 The AASHTO Classification of soils and soil-aggregate mixtures.

$$GI = \underbrace{(F - 35)}_{1 \text{ to } 40}[0.2 + 0.005(\underbrace{LL - 40}_{1 \text{ to } 20})] + 0.01\underbrace{(F - 15)}_{1 \text{ to } 40}\underbrace{(PI - 10)}_{1 \text{ to } 20}$$

Perbandingan USCS dan AASHTO

TABLE 3-7 Comparable Soil Groups in the AASHTO and USCS Systems*

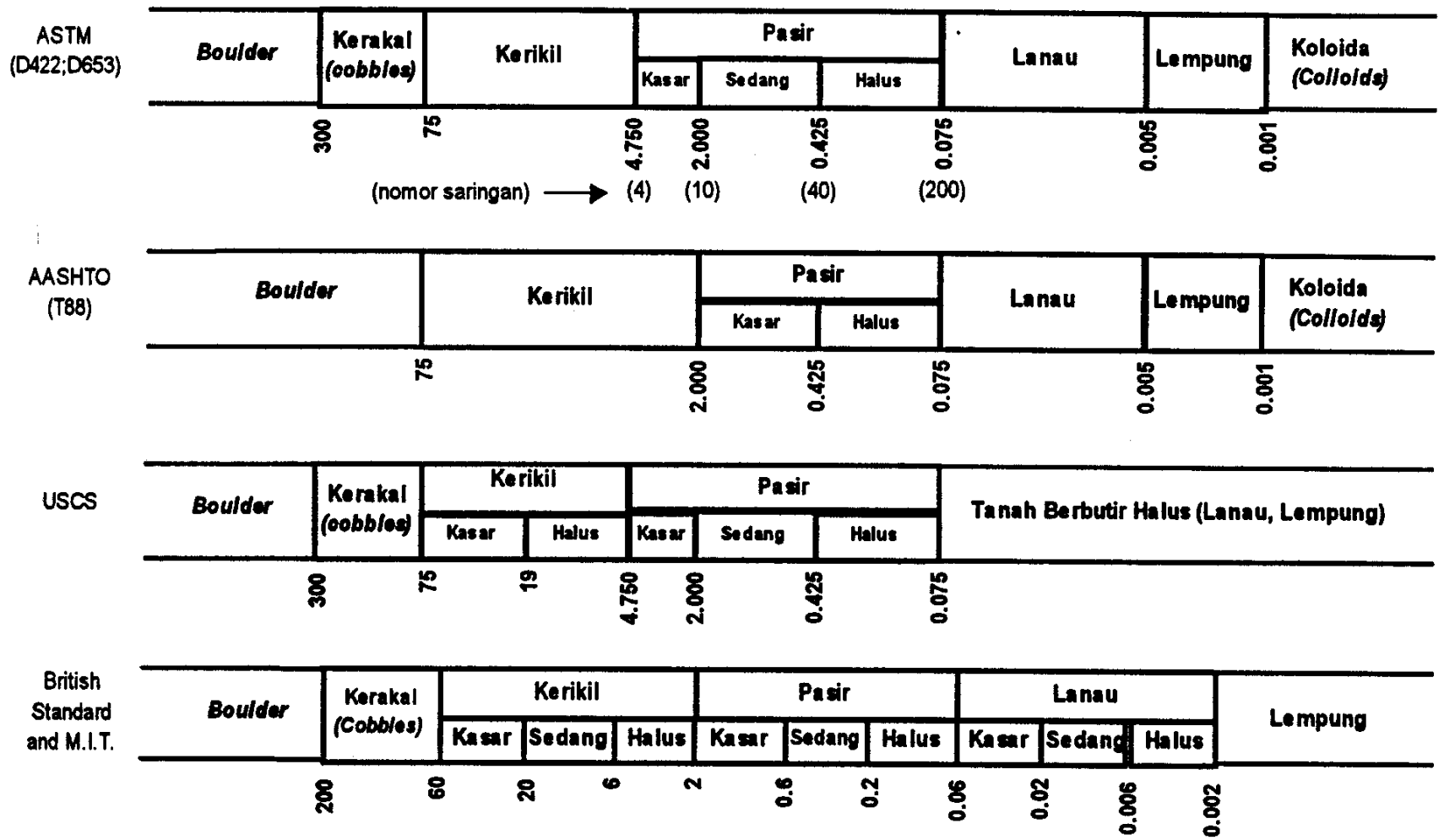
Soil Group in Unified System	Comparable Soil Groups in AASHTO System		
	Most Probable	Possible	Possible but Improbable
GW	A-1-a	—	A-2-4, A-2-5, A-2-6, A-2-7
GP	A-1-a	A-1-b	A-3, A-2-4, A-2-5, A-2-6, A-2-7
GM	A-1-b, A-2-4, A-2-5, A-2-7	A-2-6	A-4, A-5, A-6, A-7-5, A-7-6, A-1-a
GC	A-2-6, A-2-7	A-2-4, A-6	A-4, A-7-6, A-7-5
SW	A-1-b	A-1-a	A-3, A-2-4, A-2-5, A-2-6, A-2-7
SP	A-3, A-1-b	A-1-a	A-2-4, A-2-5, A-2-6, A-2-7
SM	A-1-b, A-2-4, A-2-5, A-2-7	A-2-6, A-4, A-5	A-6, A-7-5, A-7-6, A-1-a
SC	A-2-6, A-2-7	A-2-4, A-6, A-4, A-7-6	A-7-5
ML	A-4, A-5	A-6, A-7-5	—
CL	A-6, A-7-6	A-4	—
OL	A-4, A-5	A-6, A-7-5, A-7-6	—
MH	A-7-5, A-5	—	A-7-6
CH	A-7-6	A-7-5	—
OH	A-7-5, A-5	—	A-7-6
Pt	—	—	—

*After Liu (1970).

TABLE 3-7 Continued

Soil Group in AASHTO System	Comparable Soil Groups in Unified System		
	Most Probable	Possible	Possible but Improbable
A-1-a	GW, GP	SW, SP	GM, SM
A-1-b	SW, SP, GM, SM	GP	—
A-3	SP	—	SW, GP
A-2-4	GM, SM	GC, SC	GW, GP SW, SP
A-2-5	GM, SM	—	GW, GP, SW, SP
A-2-6	GC, SC	GM, SM	GW, GP SW, SP
A-2-7	GM, GC, SM, SC	—	GW, GP, SW, SP
A-4	ML, OL	CL, SM, SC	GM, GC
A-5	OH, MH, ML, OL	—	SM, GM
A-6	CL	ML, OL, SC	GC, GM, SM
A-7-5	OH, MH	ML, OL, CH	GM, SM, GC, SC
A-7-6	CH, CL	ML, OL, SC	OH, MH, GC, GM, SM

Kalsifikasi Tanah berdasarkan Ukuran Butiran



Jenis Tanah

Group Symbol	Compaction Characteristics	Compressibility and Expansion	Value as Embankment Material	Value as Subgrade Material
GW	Good	Very Little	Very Stable	Excellent
GP	Good	Very Little	Reasonably Stable	Excellent to Good
GM	Good	Slight	Reasonably Stable	Excellent to Good
GC	Good	Slight	Reasonably Stable	Good
SW	Good	Very Little	Very Stable	Good
SP	Good	Very Little	Reasonably Stable when Dense	Good to Fair
SM	Good	Slight	Reasonably Stable when Dense	Good to Fair
SC	Good to Fair	Slight to Medium	Reasonably Stable	Good to Fair
ML	Good to Poor	Slight to Medium	Poor, gets better with high density	Fair to Poor
CL	Good to Fair	Medium	Stable	Fair to Poor
OL, MH, CH, OH, PT	Fair to Poor	High	Poor, Unstable	Poor to Not Suitable

Jenis Tanah

Group Symbol	Compaction Characteristics	Compressibility and Expansion	Value as Embankment Material	Value as Subgrade Material
GW	Good	Very Little	Very Stable	Excellent
GP	Good	Very Little	Reasonably Stable	Excellent to Good
GM	Good	Slight	Reasonably Stable	Excellent to Good
GC	Good	Slight	Reasonably Stable	Good
SW	Good	Very Little	Very Stable	Good
SP	Good	Very Little	Reasonably Stable when Dense	Good to Fair
SM	Good	Slight	Reasonably Stable when Dense	Good to Fair
SC	Good to Fair	Slight to Medium	Reasonably Stable	Good to Fair
ML	Good to Poor	Slight to Medium	Poor, gets better with high density	Fair to Poor
CL	Good to Fair	Medium	Stable	Fair to Poor
OL, MH, CH, OH, PT	Fair to Poor	High	Poor, Unstable	Poor to Not Suitable

Guide to Soil Types				
What to look for	**Appearance/ Feel**	**Water Movement**	**When Moist**	**When Dry**
Granular soils, fine sands and silts	Coarse grains can be seen. Feels gritty when rubbed between fingers	When water and soil are shaken in palm of hand, they mix. When shaking is stopped they separate	Very little or no plasticity	Little or no cohesive strength when dry. Soil sample will crumble easily.
Cohesive soils, mixes and clays	Grains cannot be seen by naked eye. Feels smooth and greasy when rubbed between fingers	When water and soil are shaken in palm of hand, they will not mix	Plastic and sticky. Can be rolled	Has high strength when dry. Crumbles with difficulty. Slow saturation in water.

Fill Materials					
	Permeability	**Foundation Support**	**Pavement Subgrade**	**Expansive**	**Compaction Difficulty**
Gravel	Very High	Excellent	Excellent	No	Very Easy
Sand	Medium	Good	Good	No	Easy
Silt	Medium Low	Poor	Poor	Some	Some
Clay	None+	Moderate	Poor	Difficult	Very Difficult
Organic	Low	Very Poor	Not Acceptable	Some	Very Difficult

Pengujian untuk Klasifikasi Tanah

- Distribusi ukuran partikel (analisa saringan)
  - Bergradasi baik (*well graded*)
  - Bergradasi seragam (*uniform graded*)
  - Bergradasi buruk (*poorly/gap graded*)
- Batas-batas Atterberg
  - Batas susut
  - Batas plastis
  - Batas cair

Pengujian Distribusi Ukuran Partikel

Sieve Analysis

Hydrometer Test

Nomor Saringan	Ukuran lubang (mm)
4	4.75
10	2
20	0.85
40	0.425
60	0.250
100	0.15
140	0.106
200	0.075

Pengujian Distribusi Ukuran Partikel

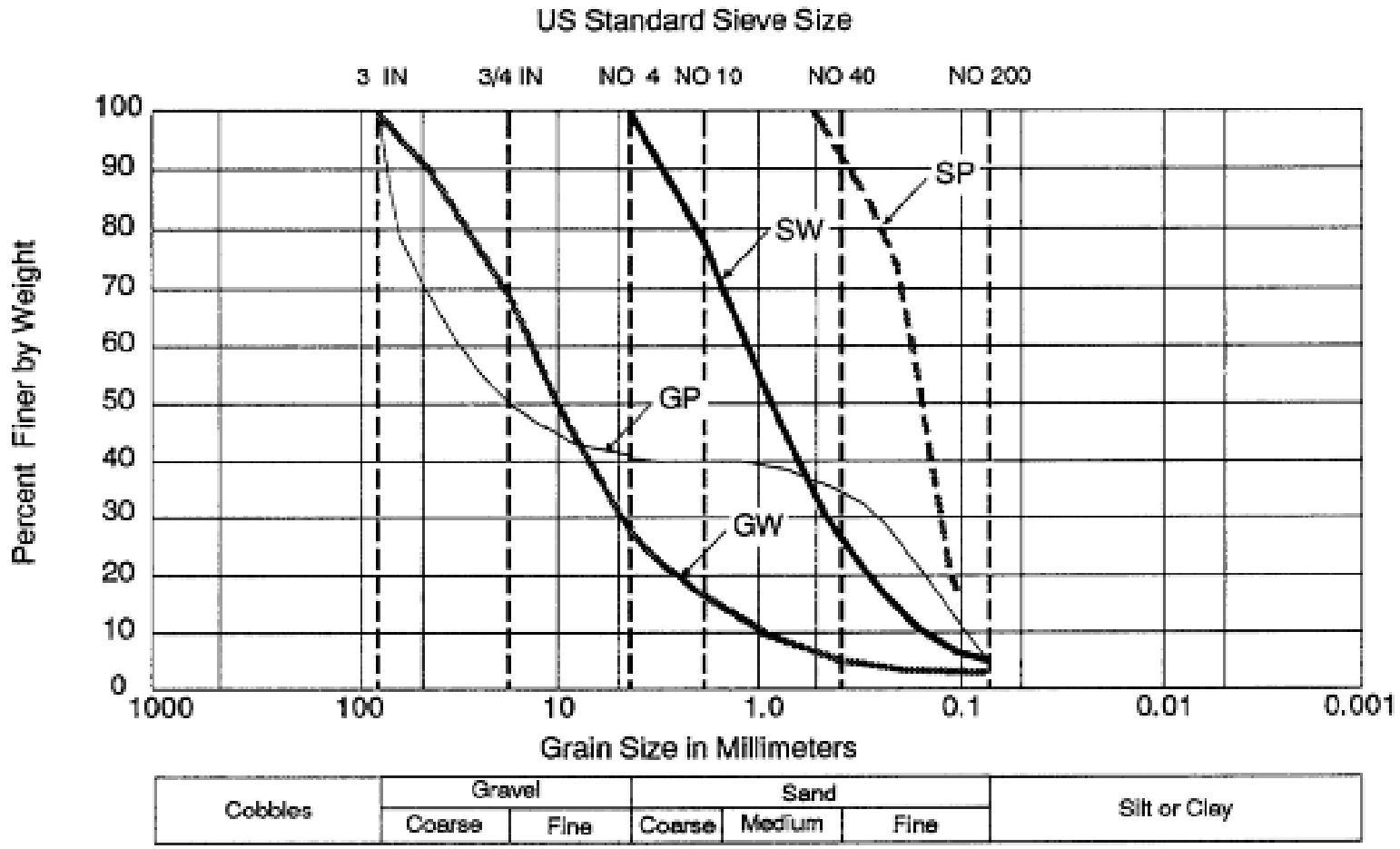
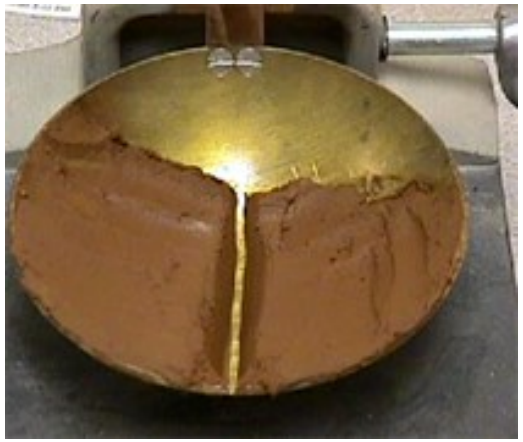
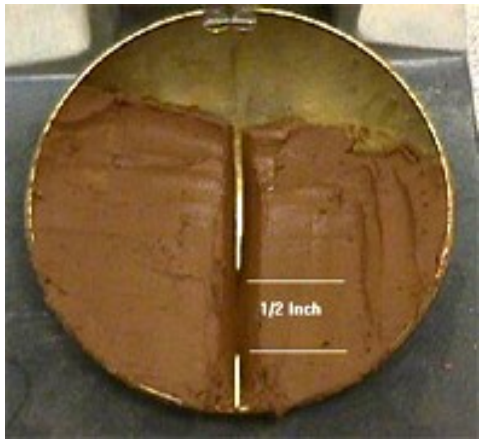


Figure 4-9. Typical grain-size distribution curves for well-graded and poorly graded soils.

Pengujian Batas-Batas Atterberg



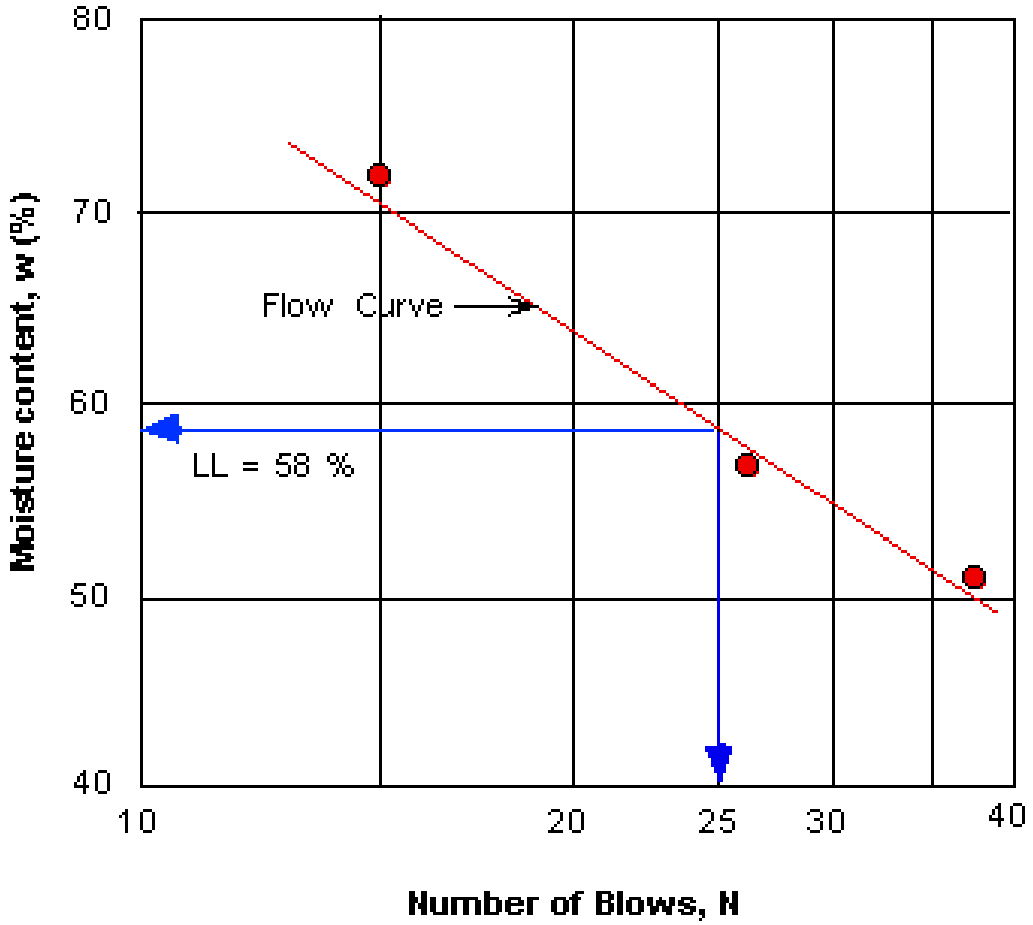


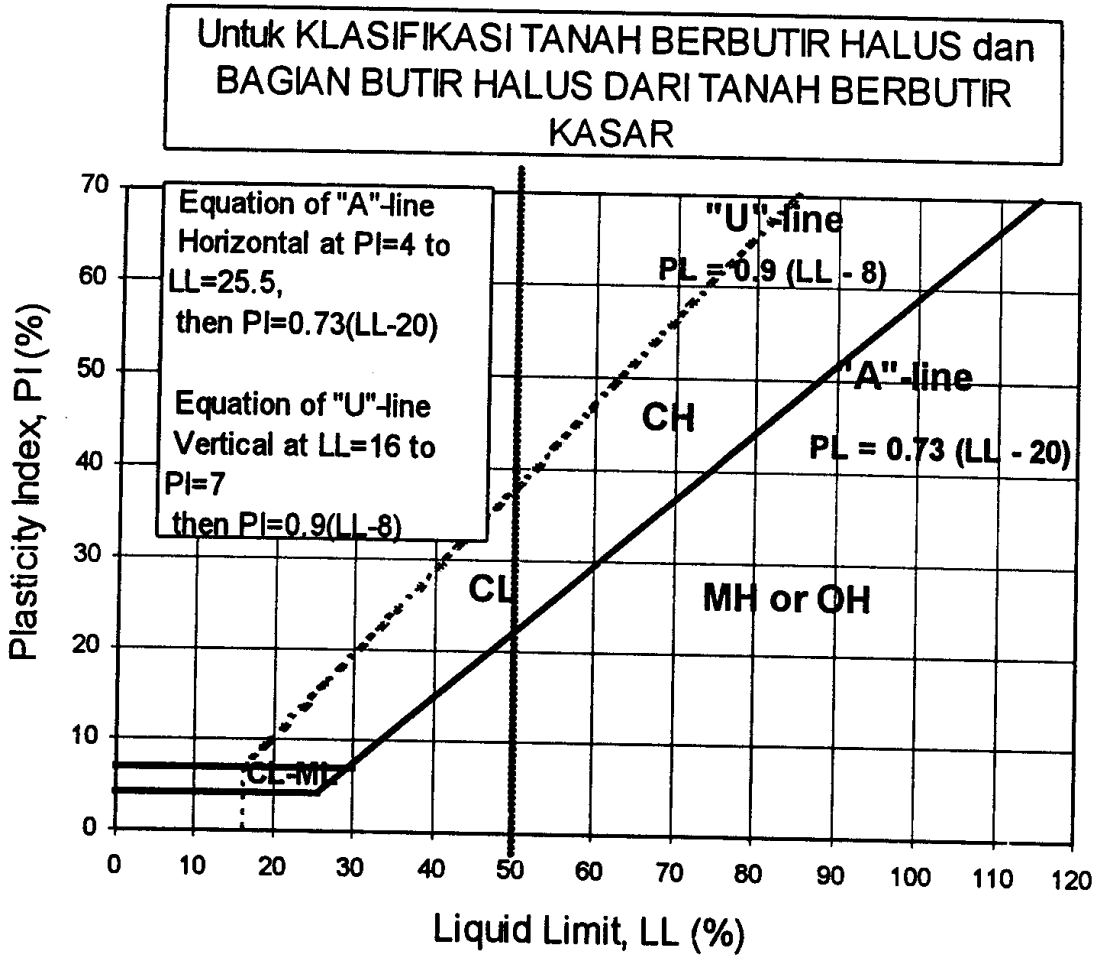
$$PI = W_L - W_P$$

$$LI = \frac{\omega - W_P}{W_L - W_P}$$

$$A = \frac{PI}{\%\ \text{fraksi lempung}}$$

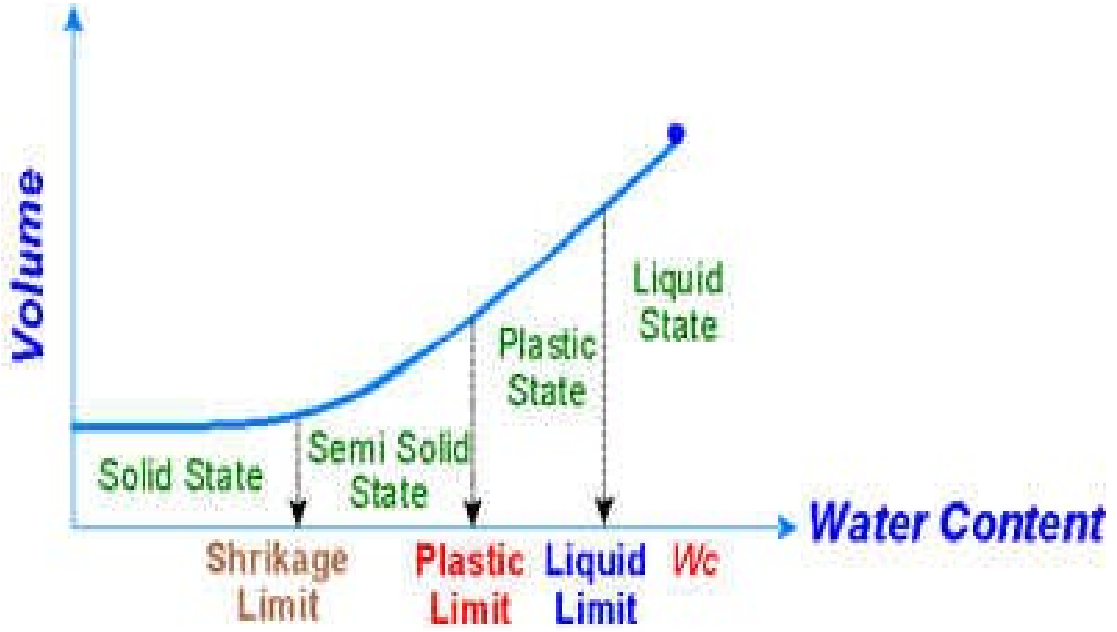
Pengujian Batas-Batas Atterberg

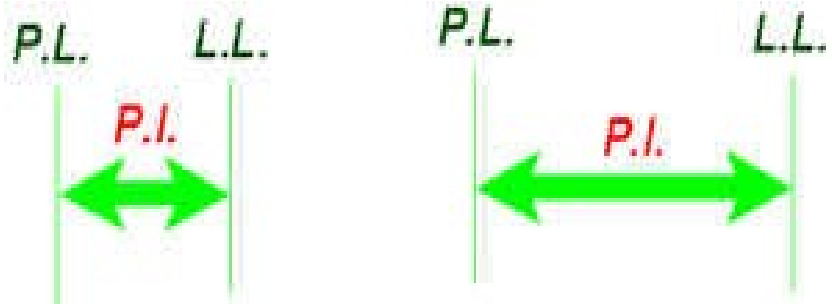




Pengujian Batas-Batas Atterberg

Salah satu karakteristik dari tanah lempung adalah plastisitasnya, yang mana hal ini tergantung dari **banyak dan jenis mineral**, dan kadar air dari lempung tersebut. Konsistensi dari tanah lempung akan bervariasi dari kadar airnya, yang terbentang antara kondisi solid yaitu kondisi pada saat kering, kondisi semi solid dan non-palstic pada kadar air yang rendah, kondisi plastik pada kadar air yang lebih tinggi dan akhirnya kondisi liquid pada kadar air yang sangat tinggi (lihat gambar).





Consistency of Clays and Atterberg Limits

- Shrinkage Limit, SL atau ws, adalah kadar air yang mendifinisikan batas antara kondisi solid dan kondisi semi soilid atau kondisi non-plastic.
- Plastic Limit, PL atau wp, adalah kadar air yang merupakan antara lempung berada pada kondisi non-plastic dan plastic.
- Liquid Limit, LL atau wl, adalah kadar air yang merupakan batasan antara lempung berada pada kondisi cair dan kondisi plastis.
- Plasticity Index, PI atau Ip, adalah rentang dari kadar air dimana tanah berada dalam kondisi plastic dinyatakan dengan persamaan Ip = LL - PL
- Liquidity Index, LI, adalah indeks kecairan yang digunakan untuk menggambarkan kondisi lempung yang berada di lapangan, dinyatakan melalui persamaan sbb:

- dimana w adalah kadar air lempung di lapangan. Terlihat bahwa apabila IL mendekati 100%, maka konsistensi tanah mendekati batas cairnya (liquid limit), sementara apabila nilai IL mendekati 0%, maka konsistensi tanah mendekati batas plastiknya.